Ground-level NO$_2$ Concentrations Inferred from OMI

Lok Lamsal, Dalhousie University

Randall Martin, Dalhousie and Harvard-Smithsonian

Aaron van Donkelaar, Dalhousie University

Martin Steinbacher, Empa

Edward Celarier, SGT Inc.
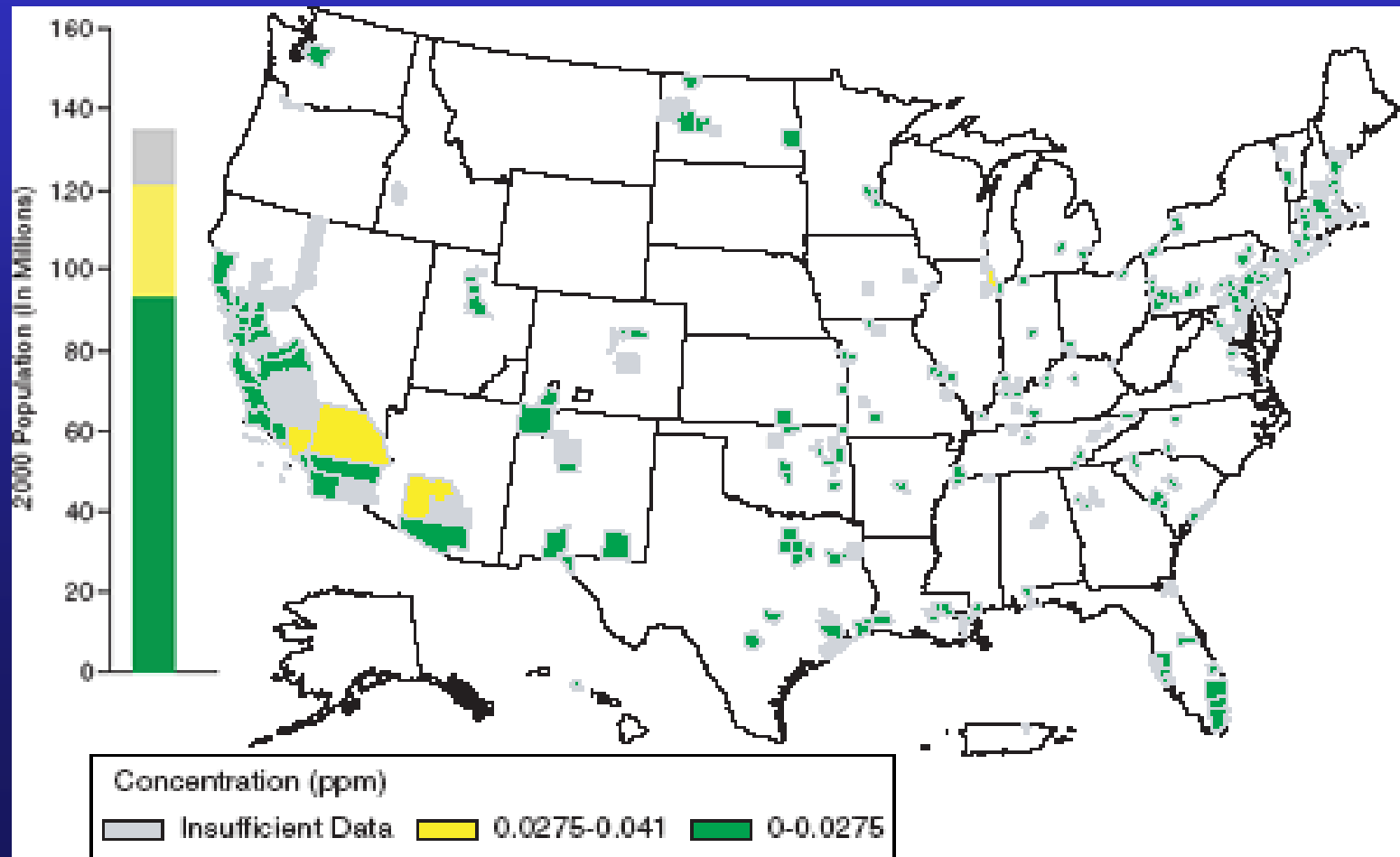
Eric Bucsela, NASA GSFC

Edward Dunlea, CIRES
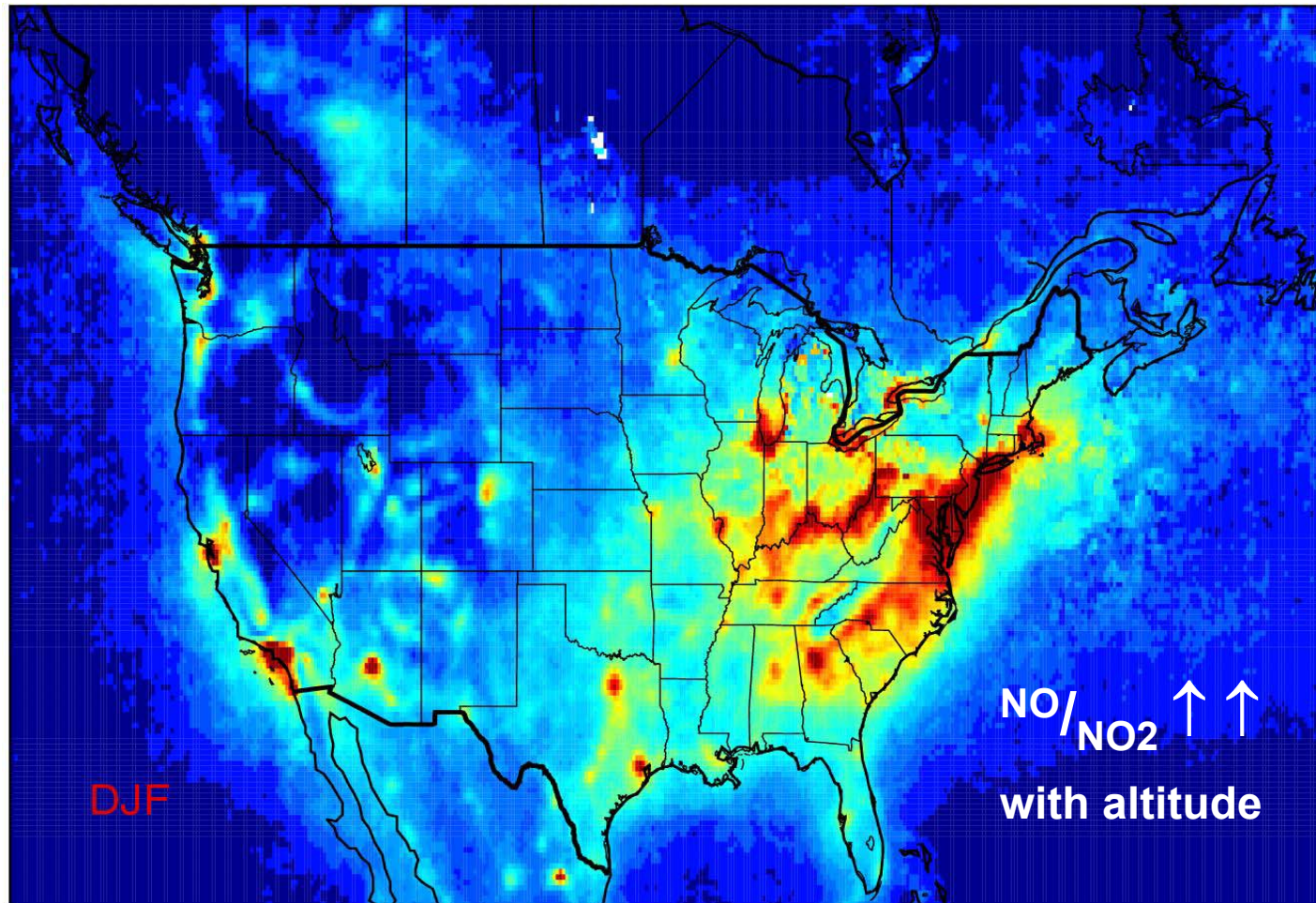
Joseph Pinto, EPA

Large Regions Have Insufficient In Situ NO$_2$ Measurements for Air Quality

NO$_2$ Toxic Pollutant Associated with Mortality
In Situ Monitors Contaminated with Reactive Nitrogen

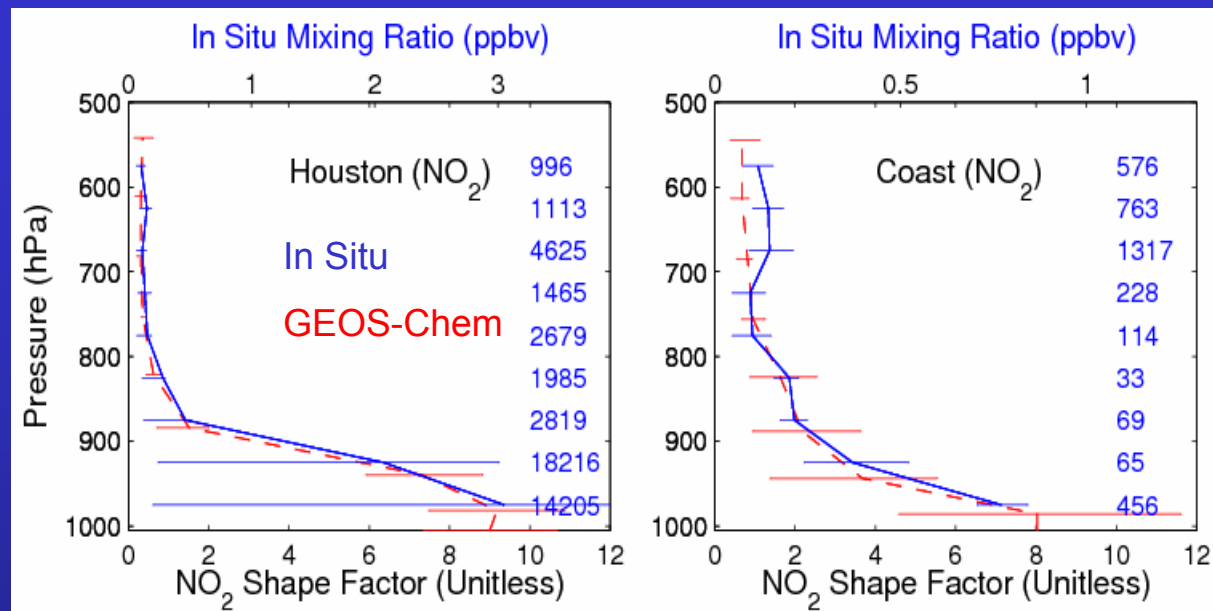### Highest NO$_2$ maximum quarterly mean by county, 2001

OMI Tropospheric NO$_2$ Column Proxy for Surface Concentration

DJF

NO/NO2 ↑ ↑
with altitude

trop. NO$_2$ column [10^{15} molec. cm^{-2}]
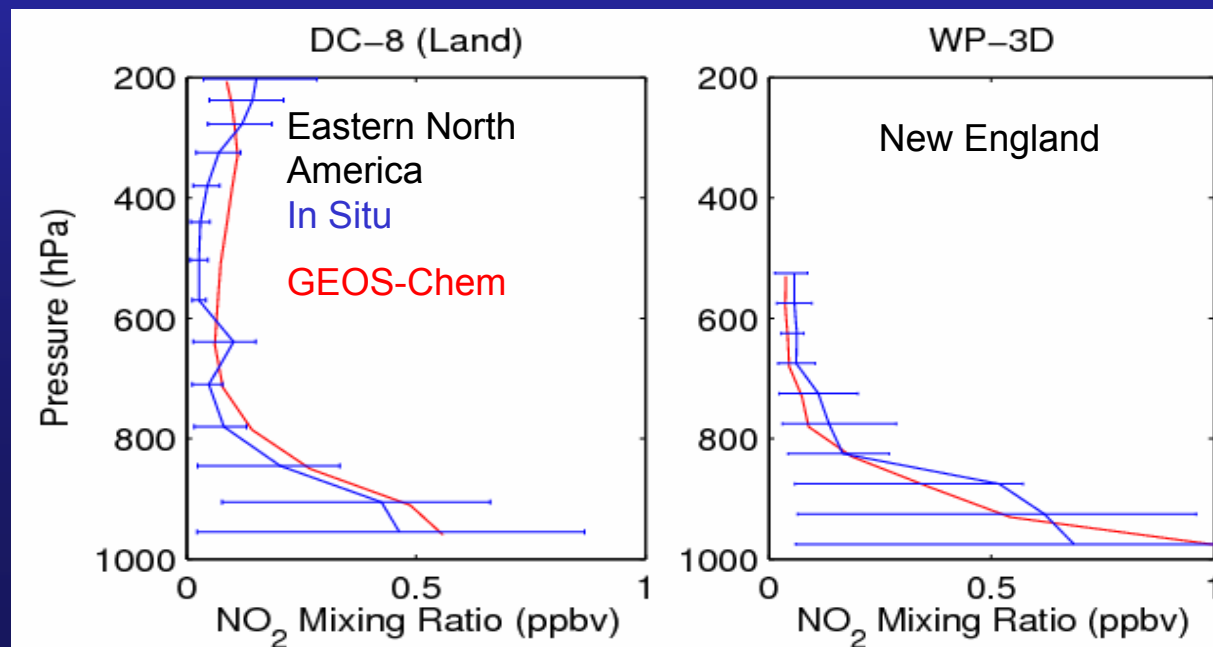
0.1 1 2 3 4 5 6 7 8 9 10

Tropospheric NO₂ Column Strongly Related to Ground-level Concentration over Land

Texas AQS

Martin et al., 2004

ICARTT

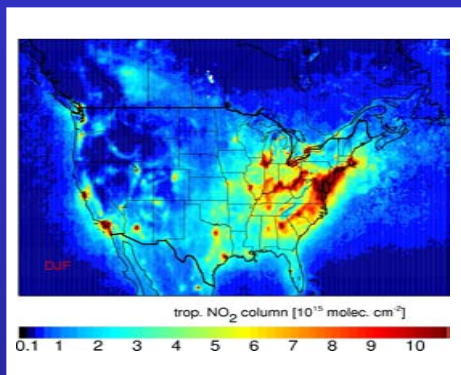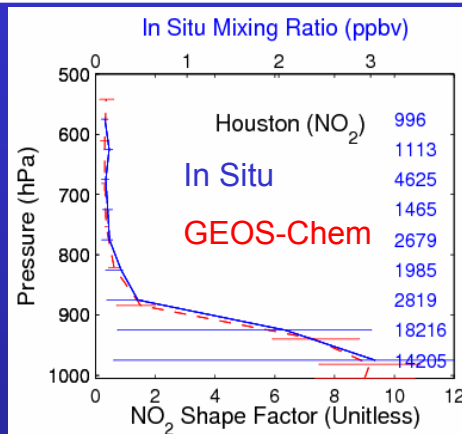Martin et al., 2006

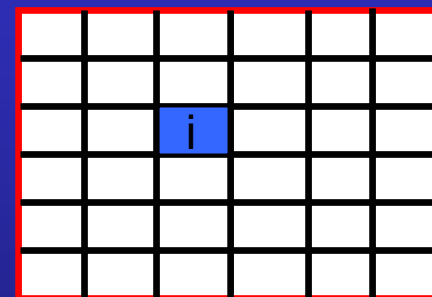# Approach to Infer Surface NO$_2$ from OMI

OMI Tropospheric NO$_2$ Column

GEOS-Chem NO$_2$ Profile

OMI Local Information

$$\overline{\Omega_{OMI}} = \sum_{n} \Omega_{OMI}(i)$$

GEOS-Chem Grid

$$S_{OMI} = \Omega_{OMI}(i) \left[\frac{S_{\text{GEOS-Chem}} \left(\Omega_{OMI}(i) \Big/ \overline{\Omega_{OMI}} \right)}{\Omega_{\text{GEOS-Chem}} + \left(\Omega_{OMI}(i) - \overline{\Omega_{OMI}} \right)} \right]$$
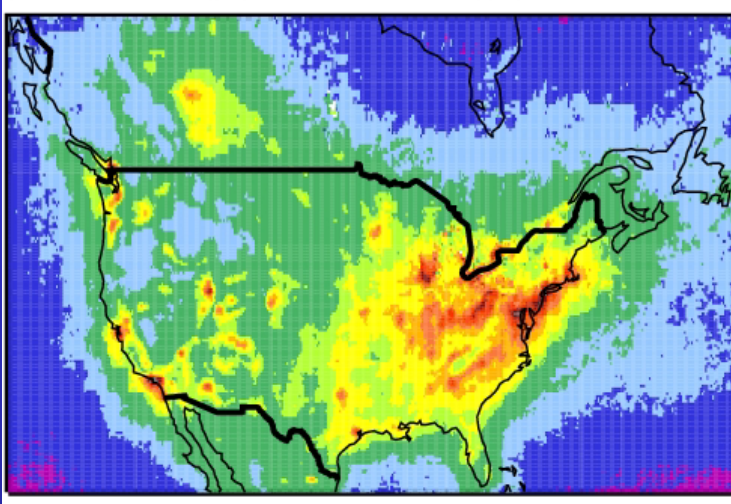
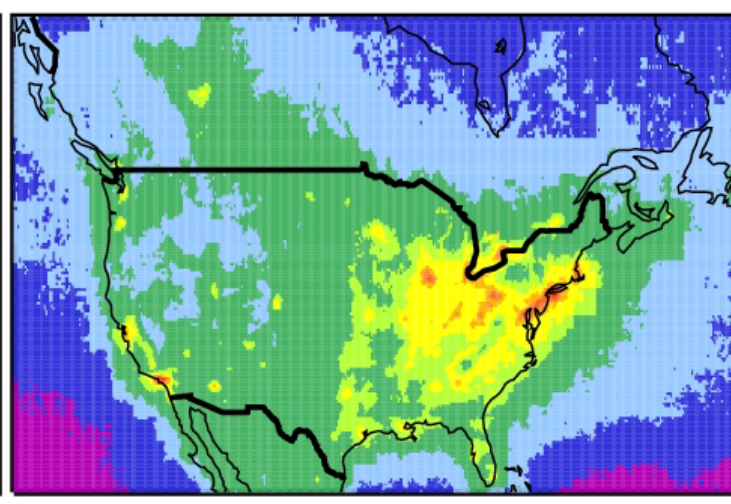**S** → Surface NO$_2$
Ω → Tropospheric NO$_2$ column

100% error in GEOS-Chem surface NO$_2$
➜ < 10% error in derived surface NO$_2$ in polluted areas

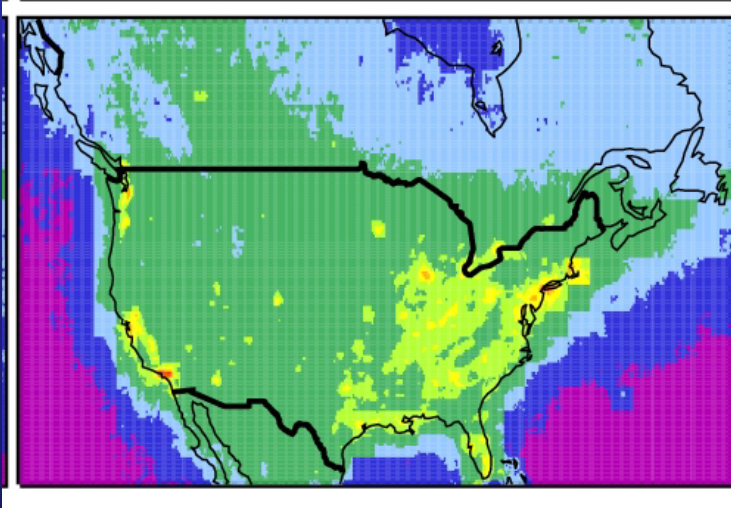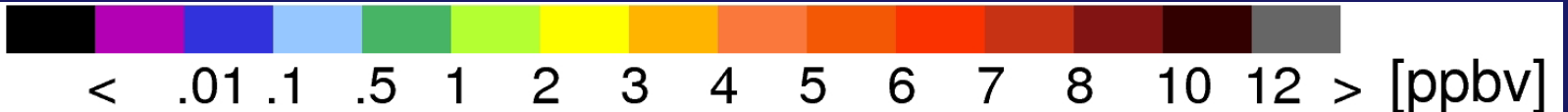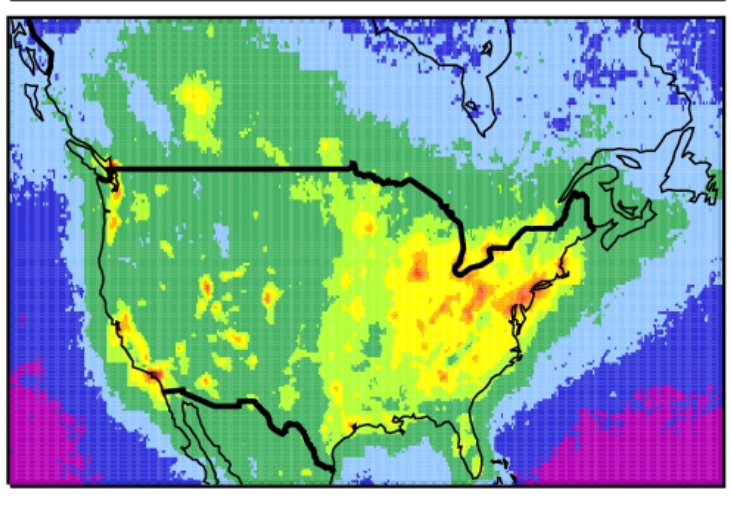Surface NO$_2$ for 2005 Inferred from OMI (standard product)

DJF   MAM

JJA   SON

< .01 .1 .5 1 2 3 4 5 6 7 8 10 12 > [ppbv]

Correction for Interference in "NO$_2$" in Air Quality Networks

Compounds	Conversion efficiency	Experiments
NO$_2$, ethyl nitrate	~ 100%	*Winer et al., 1974*
PAN	92%	*Winer et al., 1974*
HNO$_3$, PAN, n-propyl nitrate, n-butyl nitrate	≥98%	*Grosjean and Harrison, 1985*
Ammonia, gas phase olefins, NO$_3^-$	Insignificant	*Dunlea et al., 2007*

Difficult issue: Loss of HNO$_3$ on stainless steel of inlet
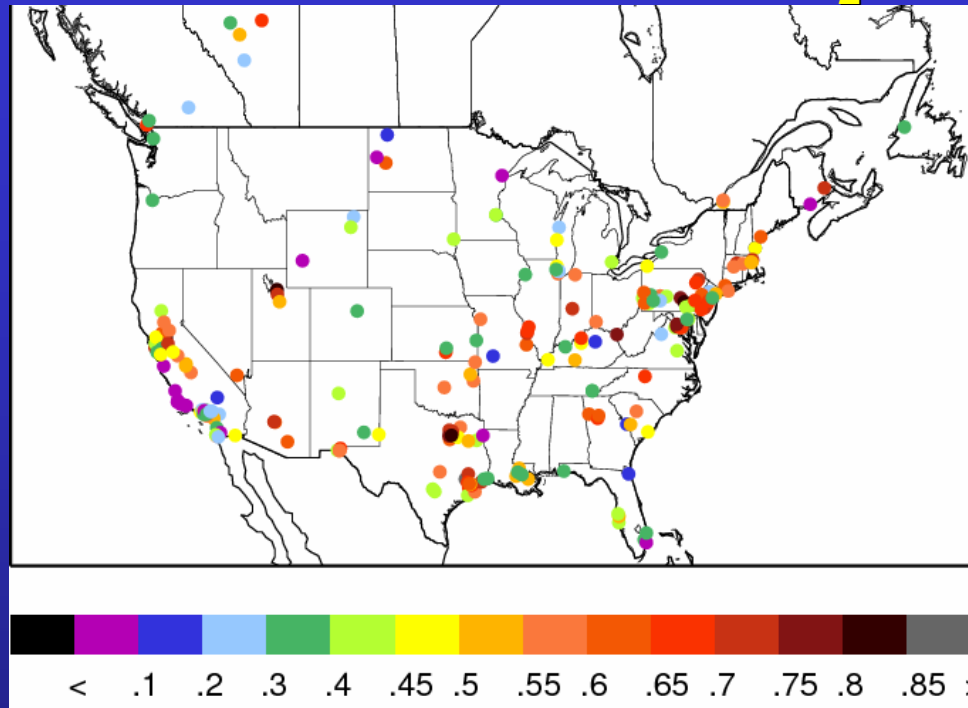
Infer 35% measured from comparison with photolytic converter

Correction Calculated with GEOS-Chem

$$Correction = \frac{NO_2}{NO_2 + \text{Alkyl Nitrates} + 0.95PAN + 0.35HNO_3}$$

DJF   MAM   JJA   SON

NO2/[NO2 + alkyl nitrates + 0.95 x PAN + 0.35 x HNO3]

< .1 .2 .25 .3 .35 .4 .45 .5 .55 .6 .7 .8 .9 >
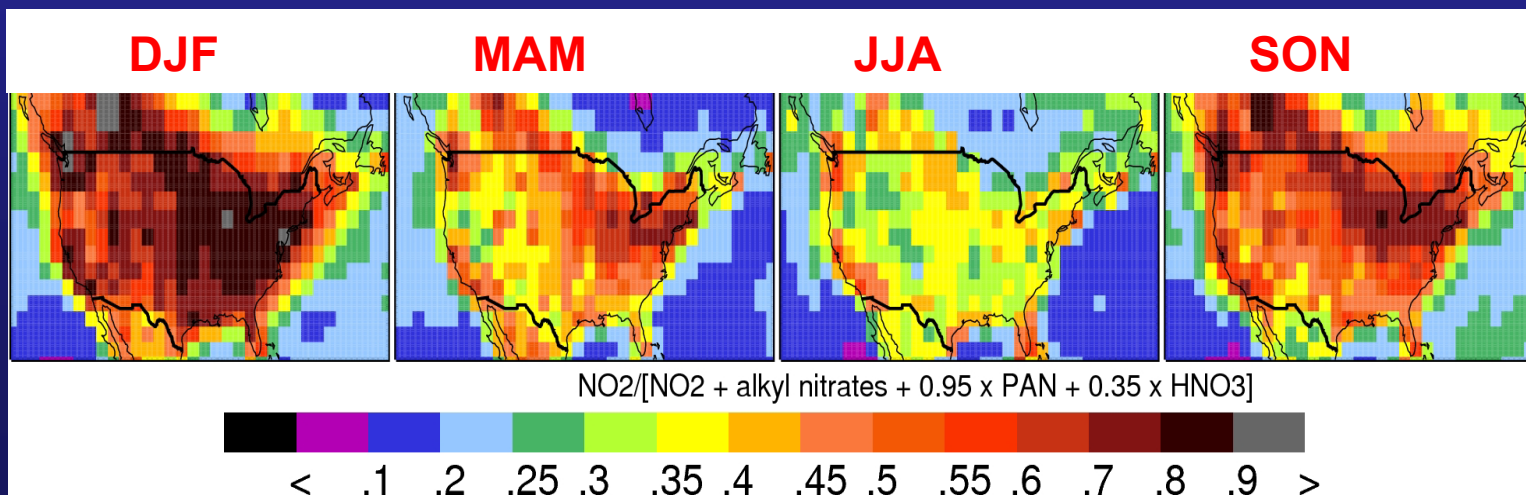
Significant Correlation Between Corrected In Situ and OMI-derived Surface NO$_2$

Correlation of Concident Observations over 2005

Color scale: < .1 .2 .3 .4 .45 .5 .55 .6 .65 .7 .75 .8 .85 >

Essex, MA [42.5N, 71.0W]

OMI-derived (standard product)
In Situ (corrected)
In Situ (orig)

NO2 [ppbv] — J F M A M J J A S O N D
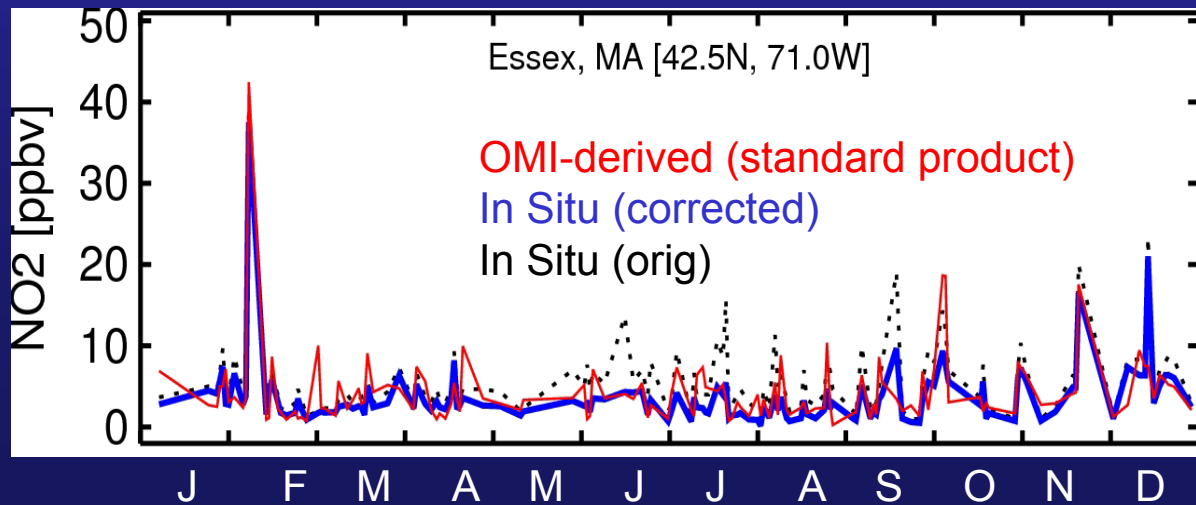
Comparison of In Situ and OMI-derived Surface NO₂ for 2005
Indirect Validation of OMI

DJF · MAM · JJA · SON

Corrected in situ

OMI-derived (standard)

< .01 .1 .5 1 2 3 4 5 6 7 8 10 12 > [ppbv]
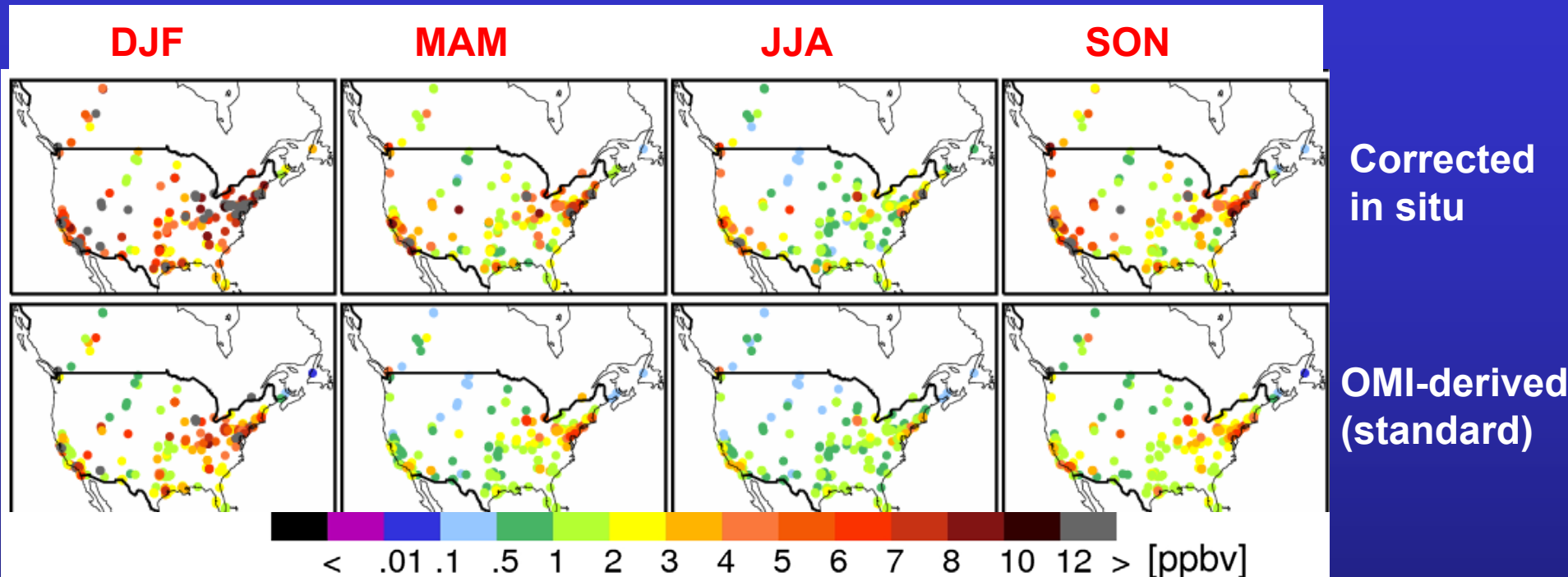
Investigation of Seasonal Bias

OMI (standard) In Situ NO$_2$

2005

rural sites

- Cannot eliminate by varying HNO$_3$ loss on inlet
- Would need factor of 3-6 seasonal bias in GEOS-Chem NO$_2$ / NO$_y$ to eliminate
- Preliminary: consistent seasonal bias vs NO$_2$ from PSS

J F M A M J J A S O N D
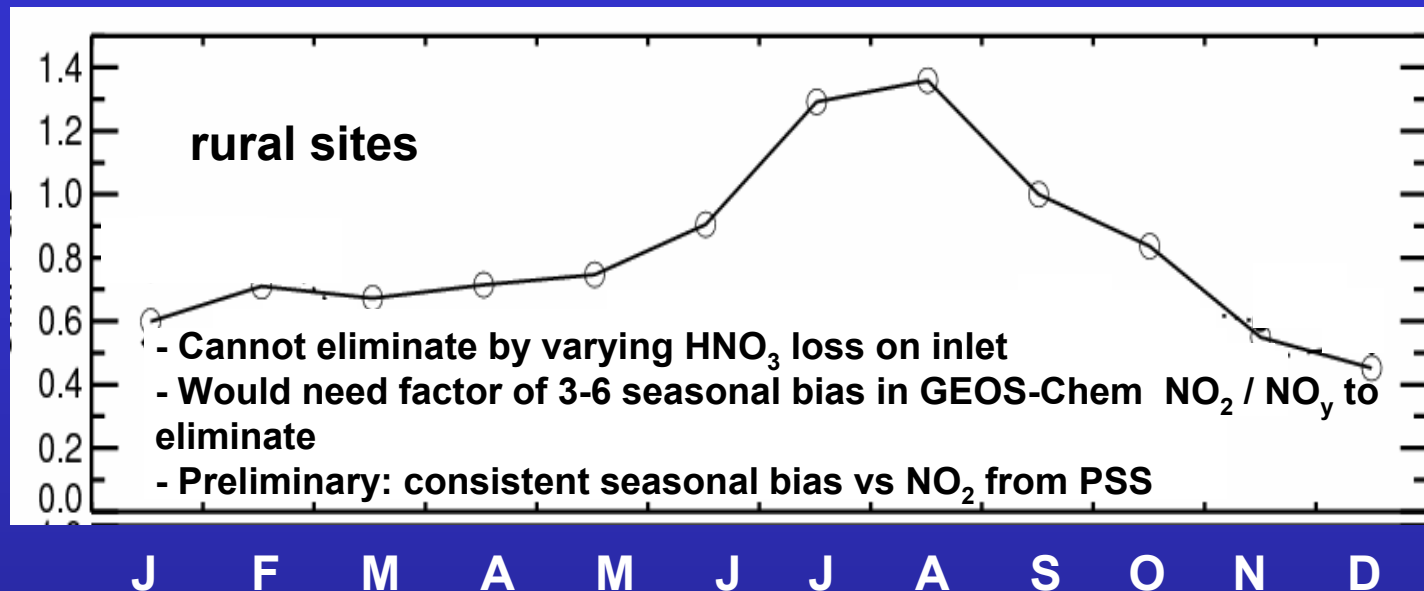
Top-down and Bottom-up Emissions over USA

Emissions

USA

OMI (standard)

OMI (NRT)

Bottom-up (NEI2002)

10^9 atoms N cm^{-2} s^{-1}

J F M A M J J A S O N D
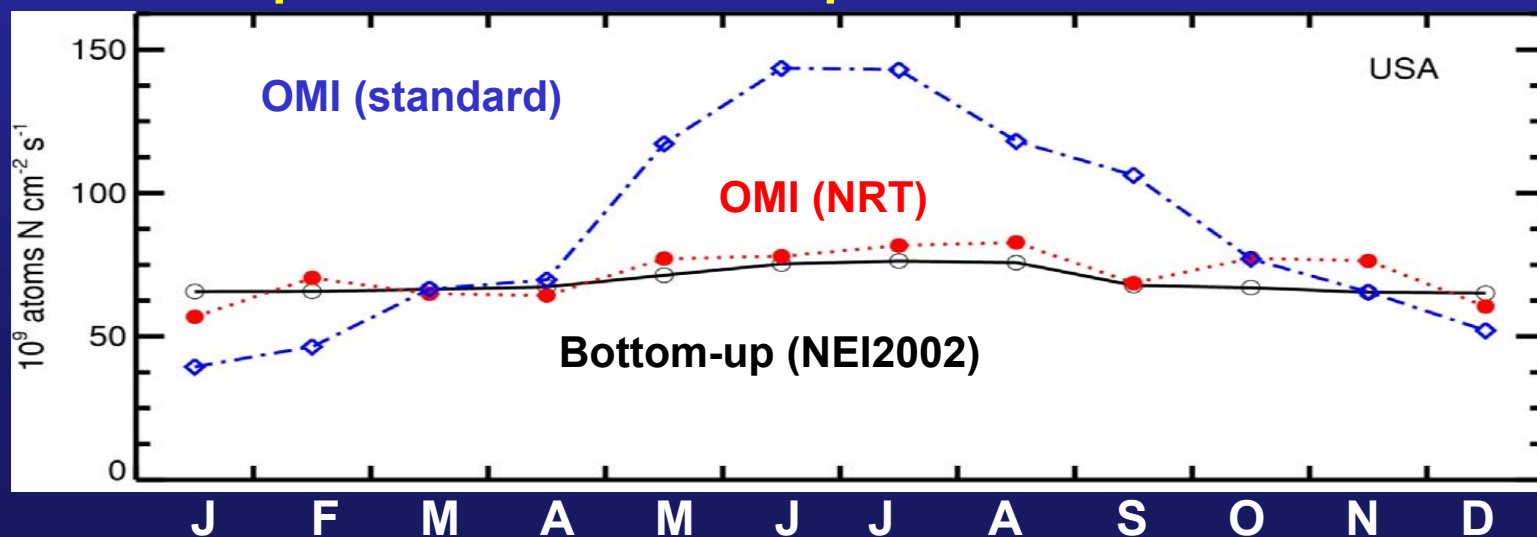
Mar 2006 – Feb 2007

Conclusions

Promising satellite-based surface NO_2 estimate

Need for additional validation of surface NO_2 with "true" NO_2

Surface measurements provide indirect validation of NO_2 columns

Acknowledgement